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ABSTRACT

Teachers' scientific knowledge about societal science issues must be one of the prerequisites for the process of science teaching. Innovation in science teaching and its implications for students' scientific literacy depends on the understanding that teachers bring with them into the classroom. The purpose of this study was to investigate how Portuguese teachers judge their own knowledge about 28 societal science issues. The exploratory survey involved 464 teachers from primary school to university level, teaching science and nonscience courses. The issues were selected on the basis of their social relevance and were concerned with such things as radioactivity, consumer education, environmental problems, and food. Results indicate that in all of the groups, more than 50% of the teachers thought that they knew very little or just a little about the majority of the themes. It is argued that if this situation is maintained, the scientific literacy of their students will probably be at risk. (PVD)

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by
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Teachers' Conceptions about Their Understanding of Societal Science Issues

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Abstract

The purpose of this study was to investigate how Portuguese teachers judge their own knowledge about 28 societal science issues. The exploratory survey involved 464 teachers from primary school to university level, teaching science and non-science courses. The issues were selected on the basis of their social relevance and were concerned with radioactivity, consumer education, environmental problems, and food, for example. The results indicated that in all the groups, over fifty per cent of teachers think that they knew very little or just a little about the majority of the themes. Despite some differences between the groups, there are some issues concerning which the teachers said they have a lack of knowledge. It is argued that if this situation is maintained, the scientific literacy of their pupils will probably be at risk.

Introduction

A deep reflection about science education has been occurring all over the world particularly in Europe and North America. Probably because the increasingly assumption that science and technology is necessary for the economic well-being of a nation, science is now a core subject in compulsory schooling in most countries. Although outside the science education community some people argue that the adult world does not require deep knowledge of science (and mathematics), there is an increasing awareness, in the developed world, that all of us need some scientific understanding to make sense of a variety of issues concerning the world. An instrumental justification for this is that scientific knowledge is necessary to make informed practical decisions about everyday

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matters, and to participate in decision-making on issues which have a scientific/technological component, in spite of the different meanings of scientific literacy for different authors (for a variety of interpretations of the term scientific literacy see, for example, Jenkins, 1990).

In spite of the enormous efforts of science and political educators to change curricula and programmes, research into students' learning in specific domains points out that very few young people aged 16 have a solid grasp of even the most basic scientific facts, principles, concepts and ideas (see, for example, Driver et al., 1994). Also surveys of science understanding amongst the adult population show they have little understanding and many potentially serious misunderstanding of basic ideas (Durant et al., 1989). This state of affairs has generated a broad consensus about the need to improve the scientific literacy of students and of the population in general. This has been argued by the AAAS, NSTA, Royal Society, Science Council of Canada and the recently launched Euroscience.

In spite of the different kinds of orientations for the science school subjects, there is a large consensus that science teaching must introduce the students to a framework of knowledge about each subject so they have something to build on in the future. One of the goals of science education is that students can understand the STS interactions and can use capabilities they already possess in exploring scientific questions. If so, they would probably understand that science is necessary to participate in discussion, debate and decision-making about science-related issues in society (Millar, 1996, 1997).

Many educators view the scientific literacy of students as the primary contribution of school, and they argue the advantages of starting with familiar social contexts, mainly at lower school levels (Ayala, 1996). This is one of the starting points for the STS movement as an innovative approach to science teaching. Indeed, students' understanding of STS interactions and the attainment of scientific literacy continues to be at the forefront of educational reform in many countries.

Where in the past, preparation for responsible citizenship was often cited as a major rationale for requiring science for all students, new STS approaches set out to formalize the societal impact of science by incorporating it directly into the curriculum. One assumption of STS education is that making science relevant to students' lives may cause them to take more interest in the subject and work harder at grasping it. As Shamos argues (1995, p. 140) "by awakening in students an awareness of societal issues that are said to be science based we may encourage them to take a great interest both in science and in the societal issues, with the result that in their adult lives they may be able to play more effective roles

as productive members of society". It is within this framework rationale that we can defend that the choice of contexts must be subordinated to their social relevance.

In this way it is our assumption that teachers' scientific knowledge about societal science issues must be one of the pre-requisites for the process of science teaching. Besides, the complexity of the majority of these societal science issues demands multiple research into the problems, given the need for all teachers (even non-science teachers) to know something about these themes. It is our conviction that innovation in science teaching and its implications in students' scientific literacy depends on the understanding, in a broader sense, that teachers bring with them into their classroom. Moreover, there is increased agreement that it is necessary to improve the background of teachers on global change science topics, seeing that, within the global perspectives which teachers must be prepared to teach, there are global systems (ecological systems), global issues and problems (environmental/natural resources issues) (Merryfield et al., 1997). Teachers also need global knowledge about the world in general as well as knowledge of contents specific to the subjects they teach.

In spite of this general position, we agree that the level of understanding about societal science issues must not be the same for all teachers and for all science-based issues. For example, although science teachers must know about the greenhouse effect more deeply, all teachers (from primary school to secondary non-science teachers) must understand what this issue involves, otherwise they will not understand the impact of technology on society.

Purpose of the Study

Little is known about how teachers, and particularly portuguese teachers, judge their own knowledge about scientific issues, and in constructivist learning this will be the first step for any inservice teacher education programme.

However, in a particularly pertinent survey of over 250 science teacher educators in 41 countries, Bybee and Mau (1986) found considerable interest in teaching about global problems, and that educators were beginning to develop ways of introducing global issues into their teaching.

The problem underlying this study is to find how portuguese teachers judge their own knowledge about societal science issues which citizens are confronted with in daily life, and what kind of differences in such judgement there are between teachers.

The research questions include:

- i) In which societal science issues are teachers less confident about their own knowledge?
- ii) Is there any difference between teachers (science and non-science, different teaching levels) about their own knowledge?
- iii) Particularly in the case of secondary school science teachers and primary school teachers what is their own position about the issues they are supposed to teach?

This is an empirically-based study and through it we will argue that the scientific illiteracy of teachers is a serious barrier to an adequate science education of their students. Evidence gathered from teachers' perceptions on the self understanding of societal science issues would be an indicator as to whether teachers have confidence in the teaching (or teaching related aspects) of these subjects in their own classes.

Subjects

The sample consisted of 464 volunteer teachers, from primary school to university, as indicated in Table 1.

Table 1. Sample of teachers involved

Teachers' School Level	Female N	Male N	Total N	Years of teaching (average)
University	22	14	36	16.9
Secondary School (Science)	109	41	150	10.4
Secondary School (Non-Science)	122	28	150	9.8
Lower School	54	33	87	12.2
Primary School	37	4	41	19.6
Total	344 (74.1%)	120 (25.9%)	464	11.9

Teachers from all teaching levels were involved in the study: primary school (aged 6-10), lower school (aged 10-12), secondary school (aged 13-18) and university (over 18). These teachers were teaching in schools belonging to a wide geographic region. The average teaching experience was around twelve years, by which we think that teachers were aware of the relevance of scientific knowledge in their teaching.

In the cases of lower and secondary schools we included an equivalent set of non-science teachers in the sample. University teachers were predominantly non-science teachers.

Instruments and data collection

The study carried out assumed an exploratory perspective both on the issues themselves, and on the teachers' own perceptions about the knowledge involved in each one.

A survey was carried out to collect, individually, the opinions of portuguese teachers about their knowledge in 28 societal science issues. The issues were selected taking into account at least two of the four following criteria:

- i) to be part of current public discussion,
- ii) to be a controversial issue in the public opinion,
- iii) to be part of the science curriculum or potentially used by teachers as an application of school science concepts,
- iv) to be a relevant issue for responsible citizenship in a democratic society.

In order to select the issues, we analysed the school science curriculum, from primary to secondary school, and mass media magazines and journals.

A first list was constructed and submitted to a validation process conducted independently by a pannel of six experienced teachers from different school levels. Each of the judges had to indicate which issues he or she thought were less important to the common citizen. An analysis of the judgements of these teachers was conducted and all the issues that were indicated, by at least two judges, were excluded.

In the final list, 28 issues were included, with no particular order. In order to appreciate the scientific areas involved, we discriminate them as follows:

1. Issues related with radioactivity problems:

- radioactivity

- radioisotopes

- nuclear fuels

nuclear power stations
nuclear fusion and nuclear fission
particles accelerator

2. Issues in the area of consumer education:

leaded or unleaded petrol
heavy metals
CFCs
natural gas
renewable energy

3. Issues concerned with atmospheric pollution:

acid rain
greenhouse effect
ozone hole

4. Controversial issues in portuguese society:

sanitary landfills
incinerators
residual water treatment stations

5. Issues concerning world environmental problems:

sustainable development
biodiversity
desertification
eco-label
biodegradable material

6. Issues related with food:

saturated and unsaturated fats
food additives

7. Issues relevant to commercial activity:

quality certification
optical label

8. Recent issues:

cloning

fullerenes

As the problem was to understand how the sample evaluated their knowledge about the selected issues, a four level scale was chosen. Each teacher was asked to indicate his or her personal position according to the scale: (1) I know very little; (2) I know a little; (3) I know well; (4) I know very well.

Although this kind of instrument does not allow to assess teachers' knowledge, it is our assumption that different levels of response for different issues chosen by each teacher would indicate different self judgements about their own knowledge, in spite of other subtleties that this kind of scale doesn't allow to observe.

Another limitation of this instrument is that two teachers can judge their own knowledge in contrasting levels, simply because they have different personal standards or they have different levels of awareness about their understanding of the world.

Data analysis and results

The analysis of data was conducted in four steps according to teaching level and relevance of the issues in each school level.

In view of the final purpose of the study, i. e. to suggest teacher education programmes, we drew our attention to the teachers' responses assigned as (1) "I know very little" or (2) "I know a little".

The sample (Table 1) includes teachers with different degrees of education in science. In general we can say that secondary school science teachers are better prepared in the issues under discussion. This was an important reason to separate the secondary school group of teachers in two subgroups, science and non-science. As in the group of university teachers, nearly 90% had a non-science background no separation was made.

Step 1: To know how the teachers judge their own knowledge about all the issues under inquiry.

Table 2. Number of issues indicated by teachers, as knowing very little or a little, and percentage of teachers of each level that chose one of these positions in the scale

Teachers' Responses	Primary School	Lower School	Sec. School (non-science)	Sec. School (science)	University
100%	12	10	12	5	16
67%	9	8	6	11	4
50%	6	6	7	6	7
33%	1	4	3	6	1
0%					

Clarifying the meaning of the Table 2, for the primary school teachers in the sample, and for the 28 issues investigated, over 50% of teachers said that they knew very little or a little about 21 of these issues, and for 12 of them this was the feeling of over two thirds of the sample.

The analysis of Table 2 shows that the group of teachers with the best self-evaluation about their knowledge in the issues, is the one with longer science education (the secondary school science teachers). In fact, there are six issues towards which less than one third of teachers say to know little (or very little), and just five issues in which more than two thirds share the same position.

This result doesn't contradict the idea that the perception of each teacher about their own knowledge is in agreement with their type of academic background. Although the situation is not so dramatic in the case of secondary science teacher, it is worrying overall: more than fifty per cent said they knew very little (or a little) about 16 of the 28 issues.

Step 2: To identify the issues for which teachers have the same position, regardless of teaching level.

In order to answer this question, we compared the percentage of responses in each group, and ordered the issues according to the feeling of knowledge inadequacy (Table 3).

Table 3. Issues chosen by the teachers (all levels) as knowing little or very little, and percentage of teachers.

Teachers' Responses	Issues (percentage range)
67%	Fullerenes (89.3 to 97.2%)
	Sustainable development (77.8 to 97.6%)
	Cloning (72.0 to 82.9%)
	Biodiversity (70.0 to 95.1%)
33%	Optical label (47.1 to 65.9%)
	Incinerators (46.7 to 58.5%)
	Food additives (46.0 to 64.7%)
	Leaded or unleaded petrol (43.7 to 58.5%)
	Saturated and unsaturated fats (42.7 to 69.4%)
	Radioactivity (37.3 to 69.4%)
	Ozone hole (15.3 to 38.9%)

The issue relating to the teachers' less negative perception of their knowledge is the Ozone hole. This state of affairs may be justified by two kinds of reasons: it is a school subject from the primary level and a frequent issue in mass media. But although it has been included in science curricula, there are some secondary science teachers (about 15%) who claim they are not well informed.

Particularly worrying is that transdisciplinary and interdisciplinary issues as "Sustainable development" and "Biodiversity" were amongst the least well known by the teachers. And what must we think about teachers' decision-making concerning environmental issues ("leaded and unleaded petrol") and personal health ("saturated and unsaturated fats"), when more than fifty per cent of teachers say to know little (or very little) about these issues?

Step 3: To identify issues in which secondary school science teachers are less confident.

The issues chosen to carry out this study are particularly pertinent for secondary school science teachers, although their relevance depends on the subject concerned. For example, questions related with "Biodiversity" and "Cloning" would be more important for Natural Science teachers, "Fullerenes" and "CFC" for Chemistry teachers and "Particles accelerator" and "Nuclear fusion and nuclear fission" for Physics teachers. Nevertheless, taking into account these teachers' academic background in science we can assume that they will belong to the better informed group of citizens. If this is the case with science teachers it is only fair to assume that other groups of citizens are much worse.

The analysis of data supplied by secondary school science teachers shows the situation illustrated in the following table.

Table 4. Issues indicated by science teachers as knowing little or very little, and percentage of teachers.

Teachers' Responses (%)	Issues
89.3	Fullerenes
84.7	Sustainable development
72.0	Cloning
70.0	Biodiversity
67.3	Quality certification
	(17 issues)
28.0	Acid rain
28.0	Nuclear power stations
26.0	Biodegradable material
18.0	Greenhouse effect
15.3	Ozone hole
14.0	Renewable energy

All the issues indicated in the lower half of Table 4 are included in science curricula, which probably contributes for a sounder knowledge of the teachers. In spite of that there are some teachers (in some cases nearly one third of the sample) who say they know little (or very little) about them. As to the less known issues there are the most recent ones

("Fullerenes", "Cloning" and "Quality certification"), probably an important reason for this situation.

Step 4: To investigate how primary school teachers feel about these issues.

It is generally assumed that primary school is an important school level to promote children's scientific literacy and therefore curricula and teacher education play a fundamental role.

In the present study there were twenty-one issues about which more than fifty per cent of primary school teachers evaluated negatively their knowledge. Nevertheless these issues do not have the same relevance in their teaching activity. From all the issues concerned with this study, seven of them are included in the portuguese primary curriculum. But again the position of the teachers is somewhat worrying: in the case of four issues (Table 5) more than fifty per cent of teachers state knowing little (or very little) about the matters underlined.

Table 5. Primary curriculum issues and percentage of teachers thinking that they have a low level of knowledge about them

Teachers' Responses (%)	Curriculum issues
95.1	Biodiversity
65.9	Acid rain
58.5	Saturated and unsaturated fats
56.1	Food additives
39.0	Renewable energy
36.6	Greenhouse effect
29.3	Ozone hole

Limitations

There are a number of limitations in the present study: (i) it is assumed as an exploratory study from which we pretend to obtain indicators which will be deepened in future studies; (ii) the comparison between different teacher groups was done by confronting the

percentage of responses although group dimensions were not equivalent; (iii) it is not possible to guarantee the correspondence between knowledge and judgement-about-knowledge; (iv) the judgement that each person makes about their own knowledge depends on several factors which were not and could not be controlled.

Conclusions

It is not the intention of this study to justify the important role of education in science. That importance was the starting point for this research into teachers' conceptions. Throughout the study we attempted to identify what teachers think about what they know in relevant societal science issues.

This kind of knowledge is particularly pertinent in the preparation of in-service teacher education courses for two reasons: (i) teachers are citizens and they must be scientifically literate; (ii) teachers are privileged agents in student education, and nobody can enlighten somebody else on subjects they don't know enough about.

Moreover, the complexity of world issues is not compatible with a rigid disciplinary organization of scientific subjects, the main reason for the involvement of several teachers. Many of the social and economical issues in school programmes require some kind of scientific knowledge. For example, it is not possible to understand what sustainable development is without some kind of understanding of what energy resources are and the consequences of their use for the planet.

Another reason for the importance of knowing the areas of teacher knowledge that are lacking about these issues, is the opinion of some educators who point out that initial teacher training in science should focus on the development of teachers who are able to encourage effective learning in science in everyday life. So the areas of teacher competence should include an understanding of the industrial and community contexts of science (Ratcliffe, 1997). Among these contexts of science there are many controversial scientific and technological issues which have been identified as playing an important role in the teaching of science (Cross and Price, 1996), probably because of the increasing awareness that the schooling of science must prepare future citizens for participation in resolving such issues.

Therefore we argue that to introduce discussion about controversial societal issues into science teacher education courses is probably a promising way of teaching science for

social responsibility, given that the teacher remains the key to quality and effective science education for the general student.

Finally, if one of the purposes of science education is to improve the scientific culture of all pupils, it is absolutely necessary to improve, first of all, the scientific culture of the teachers.

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